KEY

Before starting please **write your name on each page**! Last name, then first name.

Take your time and **read each question carefully** to ensure you fully understand **exactly** what we are after. **Don't jump to conclusions too quickly**! Please ask us for clarification if you do not fully understand any question. You have tons of time! Good luck ecologists.

SCRATCH PAPER. The last page is scratch paper for you to use to organize your thoughts.

VERSION A

1. Each term on the left below has a matching term on right that is directly associated with it. In each space on the left write the letter of the term on the right that is the best match. (10 points).

1. Numerical response B	A. $K_2 = N_2 + \beta N_1$
2. Evolution due to competition I	B. increase in predator population
3. Metapopulation D	C. species turnover
4. Coevolution H	D. dP/dt = 1 - u/m
5. $\alpha = 1$ K	E. commensalism
6. r-selected J	F. warning colors on nasty beast
7. Competition isocline A	G. habitat variation
8. Beta diversity G	H. cuckoos and their hosts
9. Aposomatism F	I. decreased niche overlap
10. Equilibrium Theory of Island Biogeography C.	J. density-independence
	K. intraspecific competition = interspecific competition
	L. $\lambda > 1$
	M. epidemic

2. List 3 anti-predator adaptations shown by animals. (3 points)

a) __ANYTHING FROM LIST IN READER ABOUT SLIDE SHOW

b) ____

c) ____

KEY

BIOLOGY 150 Final Exam
Winter Quarter 2004

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VERSION B

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1. Numerical response C	A. dP/dt = 1 - u/m
2. Evolution due to competition F.	B. cuckoos and their hosts
3. Metapopulation A	C. increase in predator population
4. Coevolution B	D. intraspecific competition = interspecific competition
5. $\alpha = 1$ D	E. $\lambda > 1$
6. r-selected K	F. decreased niche overlap
7. Competition isocline G	G. $K_2 = N_2 + \beta N_1$
8. Beta diversity M	H. warning colors on nasty beast
9. Aposomatism H	I. epidemic
10. Equilibrium Theory of Island Biogeography L	J. commensalism
	K. density-independence
	L. species turnover
	M. habitat variation

2. List 3 anti-predator adaptations shown by animals. (3 points)

a) __ANYTHING FROM LIST IN READER ABOUT SLIDE SHOW

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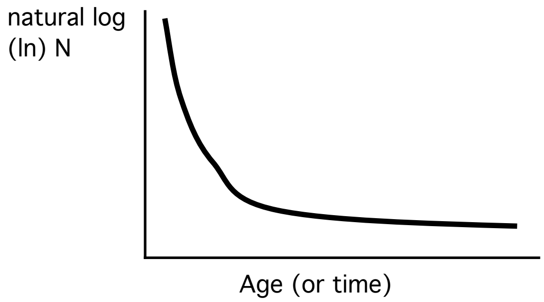
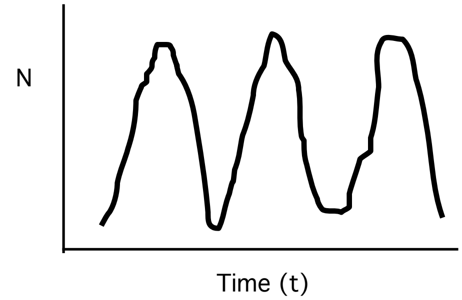
3. Fill in each graph below with the curves or lines described by the equation or phrase at the top of the graph beside the large letters. For graphs that you intend to draw a straight line, please write "straight" beside the line since it is sometimes hard to tell what you have drawn. READ EACH AXIS LABEL CAREFULLY, AS GRAPHS MAY BE DIFFERENT VERSIONS OF ONES COVERED IN CLASS!! (all 1 point except G which is worth 2 points).

VERSION A

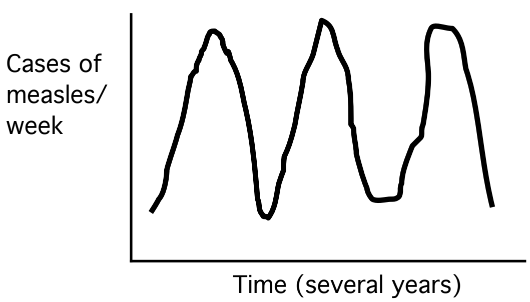
A Type III Survivorship curve



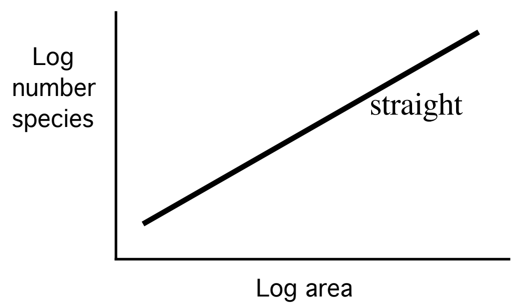
B Stable limit population cycle



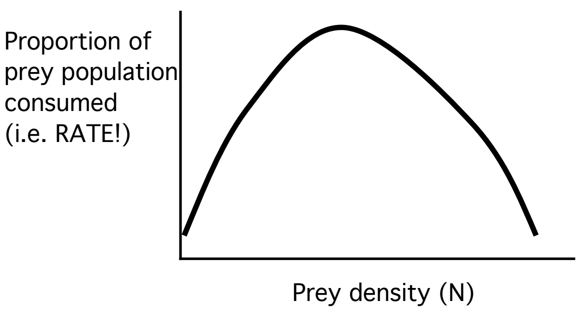
C Measles dynamics ($R_p = S\beta L$)



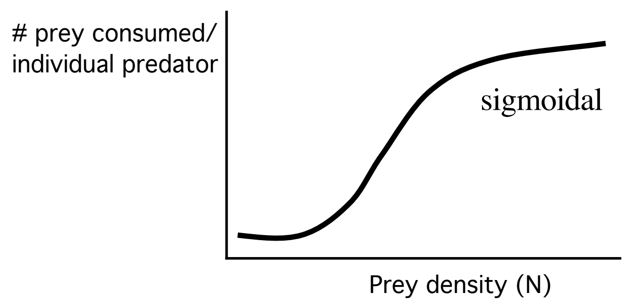
D Species area curve



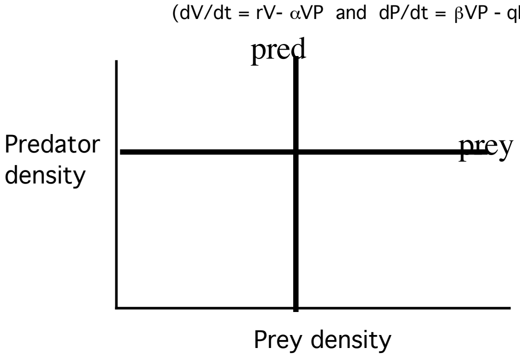
E Type III Functional response



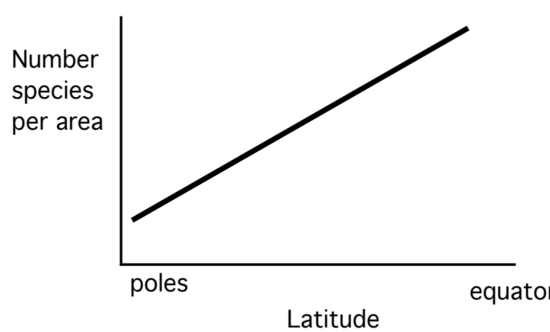
F Type III Functional response



G Predator and prey isoclines (label both)
($dV/dt = rV - \alpha VP$ and $dP/dt = \beta VP - qP$)



H Latitudinal species diversity gradient



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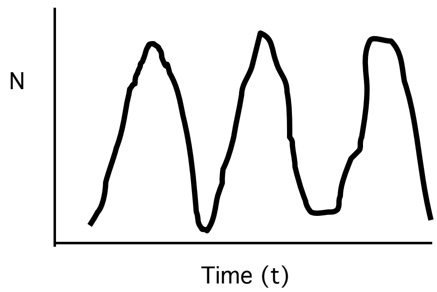

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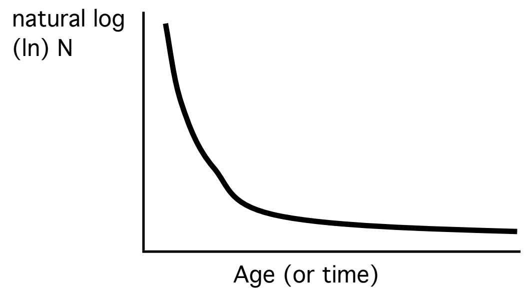
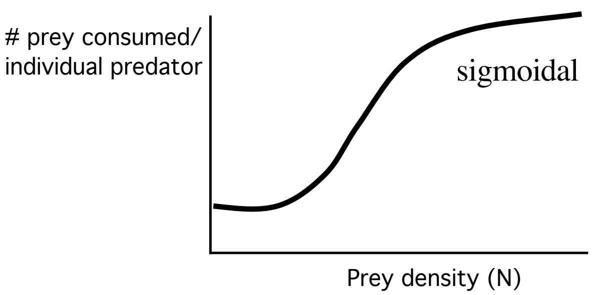
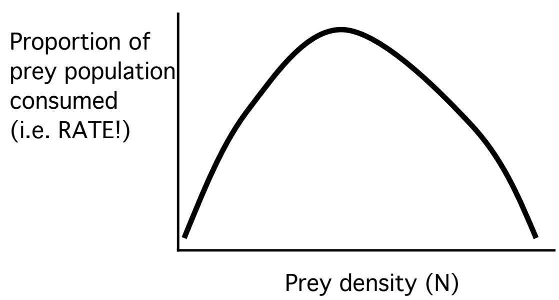


C Type III Functional response



D Type III Functional response



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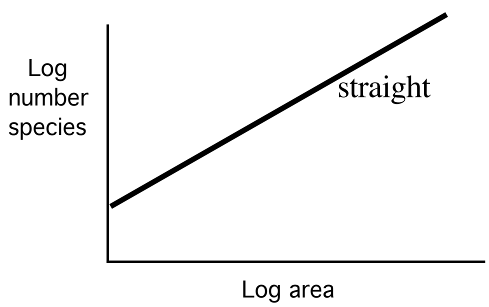

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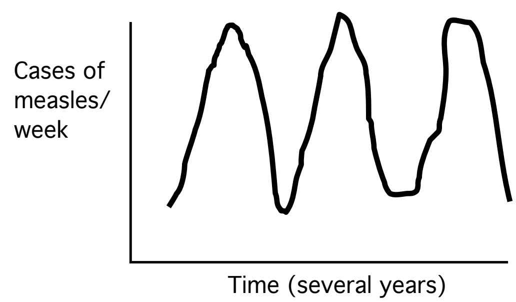

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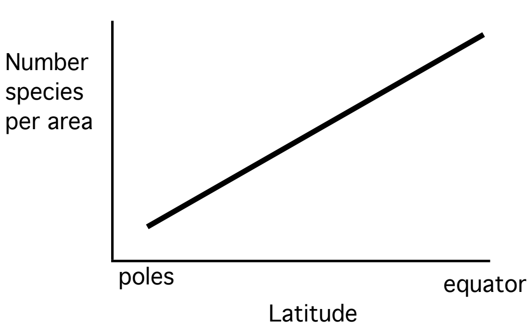

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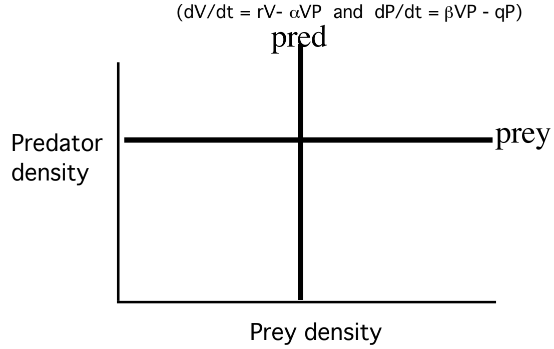
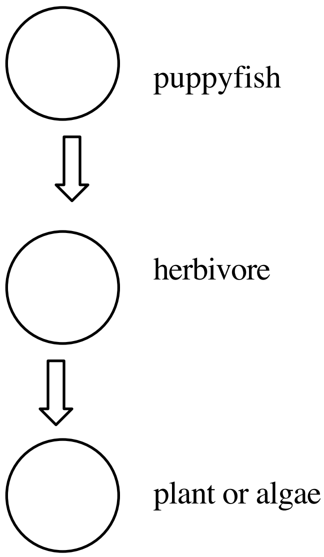


4. The following experiment is performed to assess the number of trophic levels in the food web in Scum Lake. Before the experiment, the lake is scummy green with lots of algae. Then, when you experimentally remove all of the individuals of one species, the Skinny Puppyfish, the lake quickly clears up and the algae disappear. Based on the result of the experiment, and knowledge that the Puppyfish is not a herbivore, draw the shortest food web (i.e. minimum number of trophic levels) for this lake that can account for this result. Label all trophic levels and indicate what trophic level the Puppyfish occupies. Then explain briefly in words how you determined the number of trophic levels, based on the effects that each trophic level has on the level below it, and why the removal of the Puppyfish caused the observed change. (6 points)



This is a three trophic level community. Herbivores keep plants in check in two trophic level communityso a two level system would not be green. If we have a three trophic level system with a predator on herbivores, then herbivores are kept in check and plants are released from herbivory and world is "green". Given this, the experiment incidates that we have a three trophic level communitywith puppyfish at top; removal of

5. Some organisms that live in habitats that are patchily distributed in space may have 'metapopulation' structure.

a) What two key population parameters or variables are key to understanding metapopulation dynamics and stability? Don't just give the symbols — use full words. (2 points)

extinction

dispersal (or colonization or immigration)

b) If you did a one-time survey of habitat occupancy in two species, one of which has metapopulation structure and the other one which does not, what would be the single most important difference between the two species that your survey would reveal? (2 points)

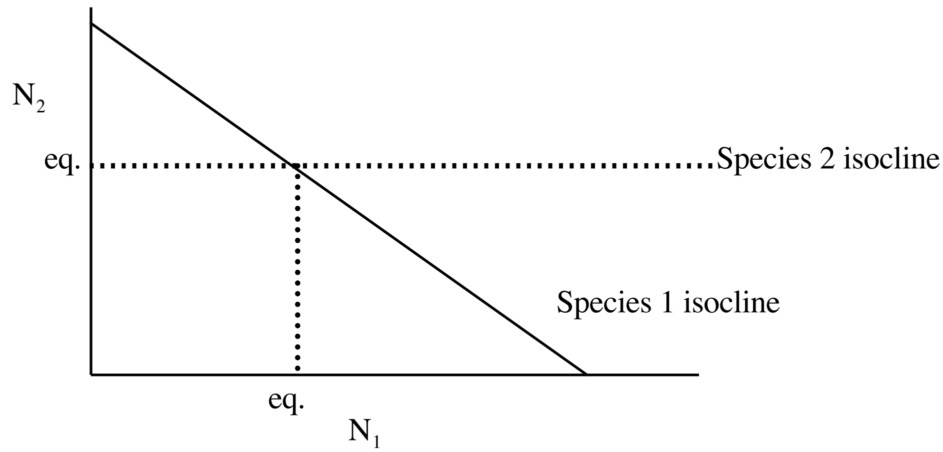
some of the patches will be empty for metapopulation species; none of patches will be empty for non metapopulation species

c) List two reasons why metapopulations matter or are interesting to ecologists or conservation biologists. (2 points)

(1) spatial dynamics matter to population analysis (2) metapopulations affect the outcome of species interaction (3) empty habitat may be essential to keep metapopulation stable

6. The Lotka-Volterra competition model allows for a graphical approach to determine the outcome of competition between two competing species. Below is a state space graph that needs to be completed for the following specific case: Species 1 does not impact the carrying capacity of Species 2 (this effect is represented by the parameter β). In contrast, Species 2 does affect the carrying capacity of Species 1 (the effect is represented by the parameter α). Despite the competition, both species can coexist.

(a) Fill in the graph below by adding the following: (5 points)
- the isocline for each species, indicating which one is for Species 1 versus Species 2
- the equilibrium point
- label both the x and the y axis (whole axis label, not specific values where isoclines intersect axes)



(b) What is the numerical value of β? i.e. β = **0** (1 point)

(c) What kind of experimental evidence would indicate that the **specific** outcome outlined above is occurring in nature? Describe both the experiment and the result from the experiment. (3 points)

reciprocal removal of each species and compare densities of each species when alone to control plots with both species

with this experiment we will see:

- **plot with species 1 removed will have same density of species 2 as controls (i.e. species 1 does not affect species 2)**
- **plot with species 2 removed will have lower density of species 1 than density of species 1 in control plots (i.e. species 2 reduces density of species 1)**

7. This question asks you to link r-and-K selection life history theory with the Lotka-Volterra competition models. According to r-and-K selection, would you expect to find r-selected species to compete in the manner predicted by the Lotka-Volterra competition models? Explain in one or two sentences why or why not? (2 points)

NO. r-selected species are assumed to be density-independent whereas the fundamental assumption of Lotka Volterrra is density dependence

8. Mortality rates have a profound influence on the evolution of many life history traits. In a transplant evolutionary life history experiment, fish are taken from Risky Lake, a lake with a very high annual mortality rate, and released into Safe Lake, a lake with very few predators where the fish now enjoy very low annual mortality (the fish were not formerly found in this lake). After ten years, the biologist returns to both lakes and studies two key life history traits in the populations in each lake, senescence and timing of maturity. Assuming that enough time has passed for an evolutionary response to the different mortality rates in Safe Lake and that there was genetic variation in all life history traits for natural selection to operate on, answer the following questions.

a) Did the fish in Safe Lake evolve an earlier or later onset (start) of senescence compared to the fish in Risky Lake, and why? Your explanation can be general but should be based on the relation between life table patterns and genes for ageing effects. (Note that the next question asks for more specific mechanisms) (3 points).

SAFE LAKE evolves later senescence because reduced mortality means that more individuals are living to older age classes than before. Now, late acting ageing genes in these age classes are affecting more individuals and they are selected out by natural selection. This pushes onset of senescence later.

b) What are two specific mechanisms or reasons for why patterns of mortality affect the evolution of ageing genes? (2 points)

mutuation accummulation (selection is weak against late acting genes)

antagonistic pleiotropy (genes with dual effects, good early effects and late-acting bad effects, are actually selected for by natural selection)

c) If you raised the fish in captivity with zero predation, which Lake has the longer average lifespan? (1 point)

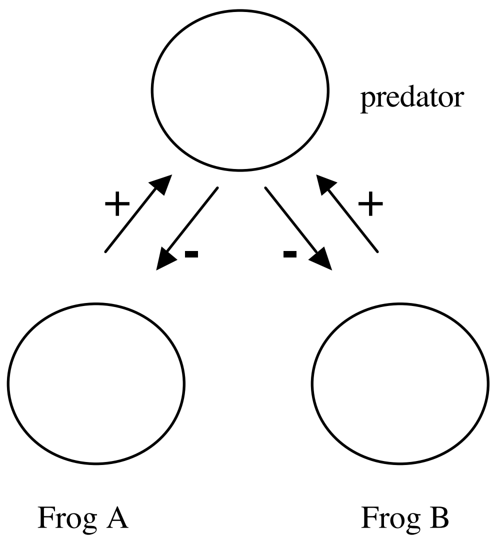
SAFE LAKE

d) Did the fish in Safe Lake evolve an earlier or later timing of maturity relative to the fish in Risky Lake and why? (2 points)

Later maturity due to a tradeoff between early and late maturation. With higher survival, the cost of waiting goes down since more individuals will live to later age classes. By waiting, individuals gain benefits like additional growth or more experience.

9. You conduct the standard reciprocal removal experiment to assess the importance of interspecific competition in two species of frogs. When you remove species A from plots, the density of species B increases, relative to control plots where both species are present. Similarly, when you remove species B from plots, the density of species A increases, relative to control plots. Although this experimental result is consistent with competition, it is also consistent with a different mechanism that does not involve competition, but instead involves other interactions. Note that in the above experiment, the only species that were manipulated were the frogs and all other players in the community were ignored.

a) What other type of interactions could explain this pattern? Use a simple drawing to illustrate the interacting species, and use arrows with either a plus or a minus sign to indicate the direct effects of each species on other species in this interaction (3 points).



In words: Predator drives pattern by having negative population effects on prey populations; prey populations have positive effect on predator population. Therefore if remove a prey species, predator population eventually goes down, other prey species then increases.

GRAPH IS SUFFICIENT

b) What is this other situation or mechanism called? (1 point)

APPARENT COMPETITION (will accept indirect effect)

c) What additional experiment, in conjunction with the experiment described above, would allow you to distinguish between competition and this other non-competition explanation? What result would support the competition hypothesis and rule out the alternative non-competition hypothesis. (3 points)

Repeat same reciprocal prey removal experiment but must also remove the predator. If we get the same density changes as the first experiment, then competition was at work. If pattern disappears with second experiment with predator removed, then competition was not involved; instead predation effects (apparent competition) caused pattern.

10. You have just completed your study of a cohort of your favorite organism, the Leapin Lizard. You began your study by ear-tagging 1000 female babies, followed the entire cohort until the last one died, and noted the number of female babies each of these female produced, on average, at each age. You then compiled all of your data and found the following: of the original 1000 newborns (age 0) you followed, 500 survived to year 1 where they had (on average) 1 baby each, 250 survived to year 2, where they had 1 baby each, 100 survived to year 3, where they had 2 babies each, and none survived to year 4.

Age	Number alive	Babies/ female		
X	s_x	b_x	l_x	l_xb_x
0	**1000**	**0**	**1**	**0**
1	**500**	**1**	**0.5**	**0.5**
2	**250**	**1**	**0.25**	**0.25**
3	**100**	**2**	**0.1**	**0.2**
4	**0**			

R_o = sum l_xb_x = 0.95

(a) Is this population growing, declining or stable? To answer, complete the life table, calculate R_o and explain, based on the value of R_o, what the population is doing. (4 points)

declining since $R_o < 1$

(b) If this population is part of a source and sink population dynamic, is it the source or the sink population and how did you know? (2 points)

sink because it is declining ($R_o < 1$ means than $\lambda < 1$)

(c) Complete the life table that will result in the following: a stable population (i.e. $R_o = 1$) of an annual plant where each adult female produces 5 seeds. Consider seeds as babies (age 0) and start with a cohort of 100 total seeds. Hint: because we are dealing with an annual organism, generation time = 1, hence $R_o = \lambda$. It might be helpful to recall our simple life history model of λ for an annual plant. You need to fill in the rest of the s_x and b_x columns and your table should also include the columns used to calculate R_o. Your answer must be complete enough that we can see how you figured this out. (2 points)

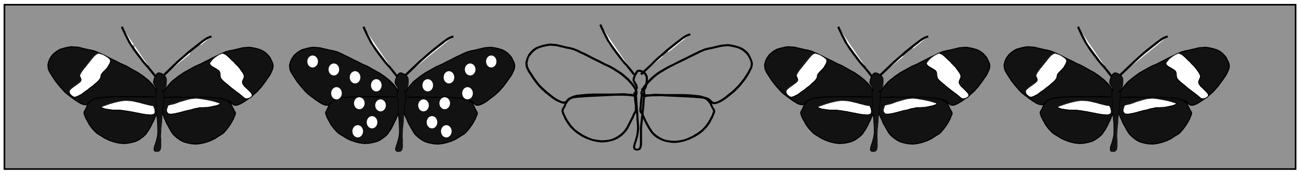
Age	Number alive	Babies/ female		
X	s_x	b_x	l_x	l_xb_x
0	**100**	**0**	**1**	**0**
1	**20**	**5**	**.2**	**1**
2				

$\Sigma\, l_xb_x$ must = 1 (this is the key point)

therefore l_x x 5 = 1

therefore l_x = .2, therefore 20 females alive at year 1

11. The diagram below shows five species of butterflies, which vary both in coloration and in toxicity. The grey background shown in the box is the natural background on which the butterflies occur. (6 points)



Species A	Species B	Species C	Species D	Species E
toxic	toxic	non toxic	non toxic	toxic

a) Identify all butterfly species (i.e. letter) that fit each of the following type of mimicry. If there is more than one species that fits a description, include all of them:

Mullerian mimicry __**A and E**__.

Batesian mimicry __**D**__.

Crypsis __**C**__.

b) Mullerian and Batesian mimicry have different dynamics, in terms of whether the convergent evolution of the signal represents cooperation or conflict between the signaling species. Explain.

Mullerian: cooperation; all toxic therefore all species benefit any time any individual of any species teaches a predator the signal is backs up nastiness

Batesian: Batesian mimics do not teach predators a lesson since they are palatable; this is bad for nasty species they copy and it destabilizes the aposomatic signal of the nasty species.

12. It is thought that mutualisms can <u>evolve</u> from interactions that start out as harmful or parasitic. What <u>specific</u> evidence from yucca moths and their close relatives provides clear support for this idea, in an evolutionary framework? Your answer should also include a brief description of the key aspects of interaction between yucca moths and yucca plants, and you should identify which specific trait or behavior was responsible for shifting the interaction from harmful to mutualistic. (6 points)

The <u>evolutionary tree</u> (phylogeny) shows that a mutualism evolved from a parasitic seed predator. The tree shows that the ancestors to the yucca moths were seed predators who laid eggs in the flower and whose larvae consumed seeds, but there was no pollination. Yucca moths are seed predators too, in that their larvae consume seeds, but they are also pollinators, and they are active rather than passive pollinators (they roll pollen in a ball and transport it between flowers and then actively pollinate the next flower they visit). The phylogenetic tree shows that pollination is a derived trait (i.e. absent in ancestors, evolved in yucca moths) and <u>that it is the key trait</u> that changed the relation from parasitic to mutualistic.